

Technology-enhanced reading performance: Defining a research agenda

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A child working on the family farm has an unfortunate accident with a combine and loses his right arm. Due to the response by the local paramedics and excellent treatment at local medical facilities, the physical wound is treated quickly. However, the trauma, loss, and grief will linger for the child and his family.

When the child returns to school, if the child was right-handed, is it reasonable for his teacher to expect that he will write his name the same way he did before the accident? Of course not. His right arm and hand are no longer available for completing the simple task of writing his name on his papers. In situations like this, the child typically receives occupational therapy services, where he is taught a variety of interventions to compensate for the physical limitations he may encounter: how to write with his left hand, how to keyboard with one hand, how to use a speech recognition system, and how to use a rubber stamp so that he can quickly sign his name.

Now, consider a second scenario. A child comes to school unable to read. Despite the best efforts of his teachers, the child is slow to recognize the letters of the alphabet. He has great difficulty in learning the sounds each letter makes. His knowledge of sight words is minimal. He has limited interest in looking at books or listening to stories. By the time the child reaches fourth grade, his reading skills have advanced to a level equivalent of a mid-year first-grade student.

Year after year, the child, his parents and teachers have tried new instructional approaches; used a variety of instructional materials; devoted extra time to reading activities; engaged peer readers to work with him; and used a host of motivational techniques to model, reward, and even coerce him to read. Despite everyone's best efforts, the child has not developed the reading skills that allow him to derive meaning from text with adequate speed, fluency, and comprehension.

These two scenarios are instructive because many educators fail to see any relation between the academic responses to the challenges each student

experiences. For example, in the first scenario they notice the obvious physical impairment demands an immediate response. However, in the second scenario, four years have been devoted to teaching a child to read with little evidence of success. We feel no remorse in demanding that certain children read like their more normally achieving peers, despite having years of data to indicate that they cannot do the task. Finally, we fail to notice the double standard we hold. In the first case, there is little interest in how the child completes the task; the emphasis is on functional performance. In the second case, we insist that the only way to read is by using the same visual, perceptual, and cognitive functions as everyone else, despite a plethora of data that points to an impairment in those organic systems.

In each of the scenarios presented, it is important to consider the event that stimulates an intervention and associated support services. Such issues are clear in the first example. However, in the second scenario, there is no single event that triggers action. Therefore, how long do we continue to provide reading instruction when a child is clearly not benefiting from it? This point is not meant to suggest that we give up teaching a child to read. Rather, at what point do we intervene with compensatory strategies, including assistive technology, to enable students to bypass, for example, the decoding aspects of reading that they have not been able to master in order to engage in the higher order processes of extracting meaning from text?

A fundamental problem for many struggling readers, their parents, and their teachers is that there are few benchmarks to guide decision making about using assistive technology when the nature of a disability is cognitive rather than physical. Given that the basic processes associated with reading and comprehending are cognitive, the field has been caught unprepared to address issues of how technology compensates for cognitive impairments (Edyburn, 2000, 2003a). Several factors may explain the lack of attention devoted to assistive technology and reading

and the minimal knowledge base that has accumulated to date.

First, the developmental roots of the field of assistive technology emerged from an emphasis in physical and sensory impairments. Second, as I have argued previously (Edyburn, 2000), the dawn of the field of assistive technology for mild disabilities in the United States can be traced to the 1997 reauthorization of Individuals With Disabilities Education Act (IDEA), which mandated that assistive technology be considered for each student with a disability when developing an Individualized Education Plan (IDEA, 1997). Third, the leading textbook on assistive technology (Cook & Hussey, 2002) fails to devote more than four paragraphs to the application of assistive technology to reading, suggesting that assistive technology personnel may be woefully unprepared to assess or implement assistive technology interventions for that foundational area of the curriculum. If we accept the premise that the field of assistive technology and mild disabilities is less than 10 years old, this fact may help us understand the lack of progress focusing on the use of assistive technology to provide nonreaders and struggling readers with technology that enables them to extract meaning from virtually any text they encounter.

Defining a research agenda

The purpose of this article is to outline four categories of issues that I believe are fundamental to understanding the efficacy of technology for enhancing reading performance. I will briefly describe each set of issues and recommend new directions that illustrate what we need to know to move forward in light of those issues. Individually and collectively, the recommendations for new directions are intended to operationalize a research agenda concerning the use of technology for enhancing functional reading performance.

What does it mean when we say a person is a reader or a nonreader?

Issues

If learning to read is a process, when does a child become a reader? Similarly, is there a process for becoming a nonreader? Whereas the developmental milestones that children achieve in the process of becoming skilled readers are well known (Snow, Burns, & Griffin, 1998), we must remain cognizant of our labels and expectations concerning

delayed readers (Rosenthal & Jacobson, 1992). For example if we identify students who can't read, how long will it take before they prove us correct? Unfortunately, when students struggle to learn to read in grades K–3, their problems are magnified in grade 4 and beyond when the predominant instructional model in schools is based on learning from print (Hynd, 1998; Sorrells & Britton, 1998). If the predominant models of learning to read remain based in print alone, many students who can't read may come to believe they can't learn.

New directions

- Successful readers typically have a rich-base of early learning experiences interacting with books. Research is needed to study the efficacy of various reading technologies such as adapted books (e.g., BookWorm, www.ablenetinc.com); text-to-speech (e.g., ReadPlease, www.readplease.com); multilingual stories (e.g., BookBox, www.bookbox.com); scan-and-read systems (e.g., Kurzweil 3000, www.kurzweilededu.com; Read and Write Gold, www.texthelp.com; WYNN, www.freedomscientific.com), and books in multiple formats (e.g., Start-to-Finish books, www.donjohnston.com) that provide physical, sensory, and cognitive access to print for developmentally delayed readers. At the present time, little is known about the effect routine access to such enhancing reading technologies have for fostering interest, motivation, engagement, and for scaffolding skill development in emergent or remedial readers.
- Questions are being raised about whether reading in digital environments may require different types of reading and literacy skills (e.g., Leu, 2006; Transliteracies, 2006). Additional research is needed to understand whether or not students who struggle to access information in print formats prefer digital text or demonstrate better skills in navigating and comprehending. What kinds of early learning experiences with technology and media foster optimal literacy development?
- Some assistive technology tools can be installed so that every word on a web page can be spoken (e.g., Reading Bar, www.readplease.com; Browse Aloud, www.texthelp.com). What role should these technologies have in reading instruction for struggling readers? At what point do these tools become essential compensatory technologies for struggling readers? Are these tools necessary and available only for those readers who clearly have need of assistive technology, or do they have application for readers

of all skill levels? How should we think about the relation between assistive technology and universal design for learning that considers the needs of all potential learners when encountering a text (see Rose, Hasselbring, Stahl, & Zabala, 2005)?

- A defining characteristic of the Information Age appears to be information overload (Swanson, 1998; Wurman, 1990). Technologies known as personal information systems (e.g., My Yahoo, my.yahoo.com) and executive clipping services (e.g., CyberAlert, cyberalert.com; CustomScoop, www.customscoop.com) enable users to create information profiles so that only relevant articles are made available to read. Further, cognitive rescaling strategies (Edyburn, 2002) allow users to simply and easily alter the cognitive difficulty of text. For example, cognitive rescaling can be accomplished with Microsoft Word's AutoSummarize feature to dynamically summarize key information in a digital text document, or by using PictureIt (www.slattersoftware.com) to add rebus images to a text document. Should struggling readers be encouraged to use personal information systems as a means of enhancing motivation to read? Should struggling readers be taught how to use cognitive rescaling tools to adjust the difficulty level of text? Do these tools result in users spending more time

or, less time reading? Should these tools be made available only to our most capable students (the parallel of the busy executive), or might they benefit everyone, or might these specialized tools be reserved for our most achievement-challenged students as a form of assistive technology?

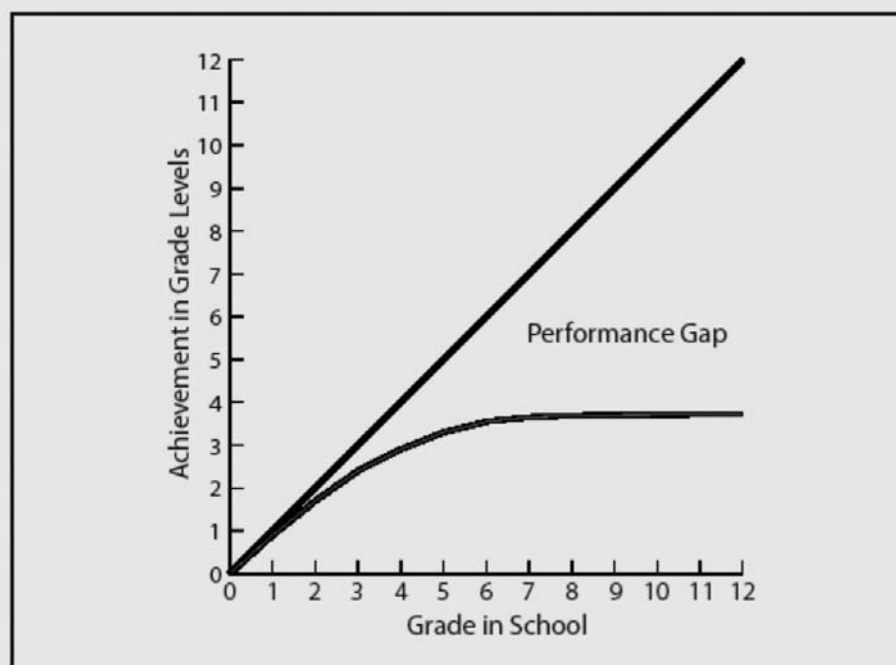
Instructional methods:

Lessons of the achievement gap

Issues

The achievement gap is a well-documented historical problem in schools (Greenwald, Hedges, & Laine, 1996; Hanushek, 1989; Haycock, 2003; Hedges, Laine, & Greenwald, 1994; Kober, 2001; Lee, 2002; Wenglinsky, 2004). The problem can be illustrated in the graph as shown in Figure 1. The diagonal line illustrates expected achievement, that is, one year of academic achievement for each year in school. However, the gray line illustrates the pattern of achievement of many under-performing students: students of color, students with disabilities, students living in poverty, and students whose first language is not English. The area between the gray line of performance by low achievers and the diagonal line of expected grade-level performance is known as the "achievement gap."

FIGURE 1



The lessons of the achievement gap are clear. First, contemporary schooling practices are not effective for all students. Second, continuing to do what we have always done, under the guise of high standards, may perpetuate rather than eliminate the achievement gap. Third, repeated failure over time creates an achievement gap that is exceedingly difficult to close (Edyburn, 2006).

Reading researchers are well aware of the achievement gap. The Matthew Effect (Stanovich, 1986), based on a Biblical metaphor about the rich getting richer, means that although young children may display small differences in reading ability, over time the differences become much larger. Effective readers exponentially become more proficient and learn more while poor readers fall farther behind. Thus, understanding the long-term effect of a reading disability is essential for analyzing and interpreting the results of data concerning the outcomes of assistive technology applications in reading.

New directions

- Despite the current federal policy priorities concerning evidence-based practice toward reducing the achievement gap, teachers and researchers must be given license to explore the application of emerging technologies with struggling readers. For example, whereas text-to-MP3 (e.g., Text Aloud, www.nextup.com; AudioBook Studio, mac.softpedia.com/get/Audio/Audio-book-Studio.shtml) is at the present time a strategy to modify texts, but is of unknown efficacy, the application of this intervention for struggling readers is worthy of examination in research and practice. Researchers must demonstrate a commitment to finding out what works, for whom, and under what conditions rather than a priori discounting the use of emerging technologies. Boone and Higgins (this issue) highlight the need to unveil the black box of technology and critically examine the instructional design embodied in our technology interventions.
- The tyranny of the textbook has created a situation where many educators believe the only way to address the achievement gap is by focusing on learning from textbooks. The promise of differentiated instruction (Tomlinson, 1999) and universal design for learning (Rose & Meyer, 2002) offers considerable potential for breaking out of the one-size-fits-all mindset. The availability of tiered digital learning materials (e.g., Ben's Guide to U.S. Government, <http://bensguide.gpo.gov>; StarChild, <http://starchild.gsfc.nasa.gov/docs/StarChild/StarC>

hild.html; Windows to the Universe, www.windows.ucar.edu) offer promising instructional design models for how to create and to deliver flexible text (e.g., audio, graphics, multiple reading/interest levels, and multilingual) in ways that encourage readers to manipulate the information so that it meets their individual needs.

Understanding and valuing the full array of academic diversity targeted by such efforts as universal design may facilitate development of a new generation of instructional materials that provide an array of on-demand supports.

Remediation versus compensation

Issues

Several theorists (Cook & Hussey, 2002; Edyburn, 2003a, 2005; King, 1999) have highlighted a critical, but overlooked, question about assistive technology consideration. That is, how do we decide if the best course of action is remediation (i.e., additional instructional time, different instructional approaches) versus compensation (i.e., recognizing that remediation has failed and that compensatory approaches are needed to produce the desired level of performance)? Because the question about remediation versus compensation is not asked routinely, it is commonly assumed that the only solution is to continue providing instruction and remediation.

The pervasive problem of children who cannot read textbooks is well documented (Allington, 2002; Cibrowski, 1993). Unfortunately, few guidelines are available to inform decision making about using assistive technology for learning. If a child repeatedly fails to read and to understand printed text, how much data documenting this failure needs to be gathered before we have enough evidence that the child can't perform the task (Edyburn, 2006)? When do we intervene? And what do we do?

New directions

- How do we determine what percentage of time and effort to devote to remediation and what percentage of time and effort to devote to compensation? Is the proportion of time and effort the same for a student in second grade as it is for a student in fourth grade? Or ninth grade? Will changing the proportion of remediation and compensation provide a balance for optimal challenge for struggling readers that sustains their self-esteem, enhancing reading-skill development, and producing gains in academic achievement? The research agenda that McKenna

and Walpole (this issue) outline suggests that the reading clinic may be an especially promising environment to study the balance of reading supports and optimal challenge for struggling readers.

- When a student is unable to read with sufficient speed and accuracy to adequately comprehend a text, is it appropriate to expect students to switch to another medium? That is, should the student know how to convert printed text into digital text? Convert digital text into text-to-speech? Or text into MP3? Or, bypass printed material altogether and to seek a media source that will provide them with the same or similar information (e.g., CNN Pipeline, www.cnn.com/pipeline as opposed to a printed newspaper)?
- As a matter of public policy, should every child that is not able to read at grade level be provided with scan-and-read technology (e.g., Kurzweil 3000, www.kurzweil.edu.com; *Read and Write Gold*, www.texthelp.com; WYNN, www.freedomscientific.com) in fourth grade when the curriculum refocuses from learning to read to reading to learn? Does such an innovation serve to narrow the achievement gap as students are able to gain access to information that was formerly inaccessible? Does current state and federal special education law concerning a free and appropriate public education (FAPE) provide a basis for mounting a legal challenge that large numbers of students with disabilities must be provided with scan-and-read technologies if they experience prolonged failure to learn to read and thus are not benefiting from FAPE?

Measurement of outcomes

Issues

The Time Series Concurrent Differential (TSCD) model described by Smith (2000) has particular merit for measuring the outcomes associated with the use of reading assistive technologies (Edyburn, 2003b). This research design requires that performance be measured with and without technology over time. Thus, it is particularly well suited for answering questions about the influence assistive or instructional technologies have on learning and performance. However, several issues remain that are relevant to new directions for research related to assistive technology.

New directions

- Little is known about whether technology engages reluctant readers in reading. As a result, research

studies that utilize the TSCD model will have a basis for comparing reading performance with technology (e.g., digital books, text to speech) and reading performance with traditional instructional materials on any relevant measures (e.g., comprehension, and time on task).

- Given what we know about learning styles and multiple intelligences, can we expect every child to benefit from text-to-speech translations? Most likely, this will not be the case. As a result, how do we discern who can benefit from text-to-speech reading interventions and who cannot?
- Several authors have created text modification taxonomies (Dyck & Pemberton, 2002, Edyburn, 2003a). Can research validate the diagnostic value and effectiveness of these interventions for modifying text and linking them with specific students (see the other contributors to this New Directions in Research department)?
- Although research on text-to-speech technology has produced mixed results to date (Strangman & Dalton, 2005), is it possible to use these technologies to provide short-term improvement in reading comprehension? If such gains can be reliably demonstrated, will such gains be adequate for closing the achievement gap with nonhandicapped peers? If not, what does this mean for measuring the outcome of the assistive technology? If assistive technology for reading shows promising potential in short-term gains, should that result trigger intensive AT-based remedial interventions to close the multiyear gap? What measures can best be used to document that the achievement gap is closing for students using assistive technology?

Conclusion

Academic performance that is achieved without the aid of external devices and resources is prized over performance that is dependent on tools or resources. Although this may be a historical artifact of society's conception of the educated person, is it time to rethink what it means to know something when a simple Google search can retrieve or verify information externally? Researchers of assistive technology outcomes have termed this form of bias, "naked independence," as it exalts the performance of able-bodied individuals and devalues the performance of others that must rely on external devices or tools (Edyburn, 2003b). Similarly, Hehir (2005) has noted that "ableism" is an insidious form of discrimination that creates barriers for individuals with disabilities

based on the cultural attitudes of the able bodied. For example, he observes that most people value intrinsic spelling ability and devalue the performance of those individuals who rely on spelling checkers.

The bias of naked independence may help explain resistance to using assistive technology with struggling readers. For example, reading historically has been a visual/perception cognitive process that was completed entirely within one's head; until recently there was no assistive technology to compensate for the internal processing necessary to read. Today the technology marketplace offers a wide variety of possibilities for struggling readers. Yet in my experience, teachers and administrators often react strongly and negatively to text-to-speech tools. They argue that allowing a child to use such a tool amounts to endorsing cheating. They argue that a student using such products can't really perform the task like the other students. They argue, instead, that students who use assistive technology are dependent on external tools. They wonder how students will be able to read when they aren't connected to a computer, even when there might be overwhelming data to show that particular students can't read without such assistance. They argue that the student can't possibly earn an A like other students who successfully read without relying on a tool to help them. And they argue that allowing a student to use a text-to-speech tool is not fair to the other students, particularly high-achieving students who earn their A's independently or other low-achieving students without access to technology. Finally, as an example, they argue that we should prevent students from using text-to-speech software because this form of technology will not be allowed on the state's high-stakes proficiency test.

Clearly the conversation about technology-enhanced performance can be contentious. The notion that technology can be used to enhance performance challenges traditional entitlements held by those who can complete a task and claim that their performance (i.e., naked independence) is superior to the performance of those who must rely on technology. As we seek to capture of the potential of technology for supporting the performance of struggling readers, such bias must be overcome in the quest to provide struggling students with appropriate tools to enhance their performance, learning, and achievement.

The use of assistive technology to enhance reading performance is a relatively new and interdisciplinary field. As such, it has an inadequate research base, a lack of widely held conceptual understandings about the role of assistive technology, and an underdeveloped range of technological innovations, all of which limit the ability to confidently inform

policy and practice. As a result, there is an urgent need for significant ethical, theoretical, and empirical work regarding the nature of assistive technology for enhancing reading performance. It is my hope that the research agenda outlined in this article will facilitate that important work.

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APPENDIX

PRODUCTS

- AudioBook Studio 3.0 (website: downloadable software), <http://mac.softpedia.com/get/Audio/Audio-book-Studio.shtml>
- Ben's Guide to U.S. Government for Kids (website), <http://bensguide.gpo.gov>
- BookBox (website; downloadable books), <http://www.bookbox.com>
- BookWorm (assistive technology device), AbleNet, Inc. <http://www.ablenetinc.com>
- Browse Aloud (assistive technology software), <http://www.texthelp.com>
- CNN Pipeline (website; service), <http://www.cnn.com/pipeline>
- CustomScoop (website; service), <http://www.customscoop.com>
- CyberAlert (website; service), <http://www.cyberalert.com>
- Kurzweil 3000 (assistive technology software), <http://www.kurzweiledu.com>
- My.Yahoo (website), <http://my.yahoo.com>
- ReadingBar (website: downloadable software), <http://www.readplease.com>
- ReadPlease (website: downloadable software), <http://www.readplease.com>
- Read and Write Gold (assistive technology software), <http://www.texthelp.com>
- StarChild (website), <http://starchild.gsfc.nasa.gov/docs/StarChild/StarChild.html>
- Start to Finish Books (assistive technology software), <http://www.donjohnston.com>
- Text Aloud (website: downloadable software), <http://www.nextup.com>
- Thinking Reader (software), <http://www.scholastic.com>
- Windows to the Universe (website), <http://www.windows.ucar.edu>
- WYNN (assistive technology software), <http://www.freedomscientific.com>